March 4, 1954

Interpretation of origin and behavior of the controlling systems.

I. Review of previous discussion.

1. Purpose was to show that systems present that control genic action in manner not quite like that of Ds - Ac or that of a_1 - Dt, (which are much alike).

2. These other systems, have basic pattern however that is similar -- control of genic action; evidence suggests that segregations of controlling units occur. Meiotic segregations obtained and linkages noted. Results of somatic segregations similar to those of meiotic segregations.

II. Controlling systems revealed by the b.f.b. cycle. Concluded that they do not arise denovo but are present in the normal nucleus -- function in some precise way during the development of the organism.

a). Somatic segregations occur, changing the constitutions of the sister nuclei with respect to the controlling unit.

b). These changes result in subsequent controls of the action of specific genes.

c). For the genes to become active, some change must occur at the locus of the gene.

d). Some mechanism must be present in the nucleus that initiates these changes in nuclear organization and constitution.

e). Believe this mechanism associated with the heterochromatic elements of the chromosomes -- primary initiators of the changes that subsequently occur.

f). The pattern controlling genes, the "switch" genes, etc., may be expressions of their action.

III. The recent studies of others showing the mechanism outlined in this series of discussions:

1. Work of Brink and students on the var. P locus in maize: Have come to same conclusions regarding the controls of the patterns of variegation expressed. Have found the transposing units. Have found the twin sectors of the types described in this series and have investigated the progeny derived from them. Confirms the story here presented.

2. Peterson, in maize, has found system controlling variegation that also appears to follow the main conditions here discussed -- the controls of genic action; transpositions of the controlling unit comparable, in many respects to Ac but not Ac.

3. The studies of the "Hi" mutation factor in Drosophila by Ives and Hinton -- suggests controlled changes at certain gene loci and controlled types of chromosomal alterations that occur at specific loci.

4. Somatic crossing-over as observed by Stern. Some cases strongly suggest a controlled system in operation here to give precise types of exchanges between certain chromosome components.

5. Many suggestive cases in literature. The cytological cases are most instructive in this respect. Review will be given of representative cases

IV. According to interpretation given -- that the effects described represent those normally occurring in development -- we must account for their appearance in the stocks used here.

1. If the processes described of control of genic action occur in standard strains, their presence not readily revealed. This is because they are active at particular times, controlled in this respect, and therefore not observed as specific units unless they are called modifiers.

2. If the controls not regulated, a chaoitc situation would occur, regarding gene action, the regulation of development, the maintainence of species, etc.

3. The pattern controlling genes -- look very much like the systems outlined
   a). The patterns in flowers: strikingly controlled in many cases.
   b). The patterns of pigmented areas in the Lady Beetle -- again, a striking case of control of when the gene for pigment formation, or involved in it, is effective.

4. If one of these systems of control becomes "out-of phase" -- starts working at a different time in development, the results would be apparent. Altered times of gene action would be noted. Variegation would result.

5. The mechanism of change, as here outlined in the discussions, would make it clear that once such a system becomes "out-of-phase", it would continue to be so, and would result in the appearance of new changes in genic action, elsewhere, which then would be put "out-of-phase".

V. The interpretation described would require that in the normal development of an organism, (3) somatic segregations should occur. (1) The nuclei should not all be alike. (2) Again, changes at particular gene loci should occur at specific types, leading to nuclei with different potentialities for genic action.

1. What do we know about (2) somatic segregations? (3) About differences in genic action in different nuclei of an organism? Is there any evidence to support the above interpretations?

2. There is a vast wealth of information in support of the ideas given. These are mainly in the area of investigation known as "cytology" and much of it is purely descriptive. Many of the papers in this field are not examined by geneticists because of their highly technical nature. Most are not seen at all by biologists in other fields. The observations, however, are of vast significance. The field has only been tapped and a wide opportunity is present for experimental investigations.

3. A brief review will be given of the nature of this evidence, with examples selected for illustrations. Will cover the following topics:

(1) Differences in nuclei of organism with respect to sets present.
(2) Differences in nuclei of organisms with respect to particular chromosomes present.
(3) Differences with respect to component parts of the chromosome itself:
   (a) Large segments to (b) the minutest segments known -- the bands in the salivary gland type chromosome.

VI. Differences in nuclei of an organism with regard to the number of sets of chromosomes present:

1. Zygote -- starts out with two sets of chromosomes, one from male and one from female. During development, changes occur in the number of sets of chromosomes within the nuclei. These are controlled changes: certain types of cells having certain specific types of changes in sets. The set may increase -- poly ploid nuclei; or the set may be reduced -- to haploid nucle. These changes occur at specific times during the development of the organism. Also, different mentods of change in set number occur.

The increases in numbers of sets: By means of endomitosis -- no mitotic division figures. Various methods of accomplishing this endomitosis. Fusions

a). The degrees of increase: From tetraploid to 2,000 ploid.

b). The type of appearance of chromosomes: Polytene type - salivaries or diffuse type -- frequent; Or, combination of both.

The decreases in number of sets: Some interesting examples:

a). Tail of Rana (frog). Epidermis is diploid (Swan, 1957)
Mesenchyme is haploid (Ludford, 1953)

b). Sea Urchin: A "reduction division" in certain cells early in cleavage stage: 16 cell stage -- 4 micromeres present. These are 2n. In division of micromeres, reduction of chromosome number occurs to haploid. These haploid cells become skeletal components of organism.

b). Increase of sets followed by decrease of sets: Culex. Very well examined case to show the mechanism involved. Reduction occurs during metamorphosis period.

VII. Differences in nuclei with regard to certain chromosomes of the complement: Loss of chromosomes at specific divisions: ~~xxxxxxxxxxxxxx~~ Non-disjunctions of certain chromosomes in certain divisions; Other methods of accomplishing the same.

1. Best worked case that of Sciara: Outline on board.
   Loss of chromosomes at mitosis
   Non-disjunction of particular chromosome at certain division
   Pasage of chromosome through nuclear membrane -- highly controlled.
   The experiments that show which part of chromosome is responsible for the phenomena.
   When is this effect impressed on centromeres?
   What mechanism makes the impression so precise?

2. The B-type chromosomes in plants. Very highly controlled non-disjunctio of these chromosomes. Occur at specific times and with specific consequences.
   a). Example of this behavior -- the B chromosome in maize:
   Diagram on board.

Control exerted at centromere region of B-chromosome, as in the X chromosomes in Sciara. The translocation studies showing this.

3. Ascaris - loss of parts of chromosomes - [illegible] ends.

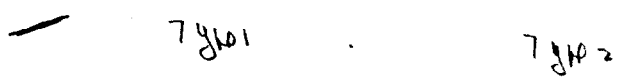
VIII. Differences in behavior of sets of chromosomes within same nucleus:
Ch. no. condensed = 28.
White . Monarthropalpus. Spermatogenesis:

→ Sperm receives chromosomes in condensed state.

IX. Differences in appearance of different chromosomes of a set in different stages.

a). The small chromosome in salivary glands of White.
" " " " " " "elland

b). The alternation in condensation of particular chromosomes:



X. Differences expressed by individual parts of chromosomes in different cells of an organism:

1). The chromocenter regions -- heterochromatin in Drosophila -- too well known to comment on.

2). Condensed versis diffuse condition of segment of a chromosome:

3). Most exciting recent case -- that of Pavan on Rhyndhisciara -- two different species studied.

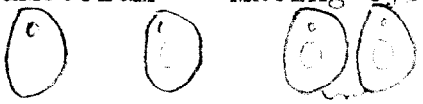
a). All eggs laid at one time -- within 45 mins.
b). "early all larve of one sex
c).All develop at same rate - 42 days to pupation. Common puparius formed
d). The changes occurring to specific bands at certain times in development in the different tissues; change at particular band specific for the tissue involved.
e). One type: at certain time, increase in D.N.A. and swelling of particular band; Separation of components of the polytene bands -- Large Puff region formed. At certain stage, shrinkage of puff region. Return to dense band, but now bad very much wider than before the process started. Increase in D.N.A. remains. Interpretaion: Multiplication of genes of this band, specifically. Differential behavior.

XI. Conclusions on nuclear compositions in organisms: Wide differences among the cells of an organism with regard to the nuclear composition. Differs with respect to sets, parts of set, parts of chromosomes, even parts of so small as a band in the salivary type chromosome.

Mechanisms : Differential behavior at certain mitoses: Losses of certain chromosomes; Non-disjunctions of controlled type at certain divisions. Passage of chromosome through nuclear membrane.

XII. Differential nuclei resulting from specific divisions: on genic level.

1. Paramoecium -- mating type reaction:



→ segregation division. Macronuclei differ in mating type. Micronuclei undamaged.

2. Tetrahymena -- mating type reaction: Same as paramoecium except the division is not as precise -- first or second division of macronucleus.

3. Case in Glomerella where mating type "mutation" occurs at specific time in development of ascogenous hyphae.

XIII. The effects of species crosses: Often quite bizaar.

1. Changes in the chromosome complement: Various polyploid conditions, reductions, occur in tissues that do not show such reactions in the individual species involved.

2. Case of Metz in Sciara: Cross of S. x S.

The mosaic salivary gland:

3. Species cross in Nicotiana. A. x B. Backcrossed to A

A.A B complement: B chromosomes eliminated somatically.

3. Altered genic action often noted; Variegation appears.

XIV. The constitution of differentiated nuclei -- as shown when these cells forced to divide.

a). Treatment of root -- chemical (indol-acetic acid). Does not affect behavior of chromosomes in the nuclei that regularly divide. Forces nuclei that are fully differentiated to divide. Then show a variety of chromosomal aberrations. One type observed in cell that had undergone endomitotic division:

The effects observed are very much like those produced by Ds.

XV. Ds type behavior in other organisms than maize:

1. Metz - Sciara. Certain chromosome, certain band region -- break seen in all salivary gland cells. Showed that this was genetically controlled.

2. Hyacinthus - Darlington. Break in a particular chromosome late in development of the sporocytes. Genetic control

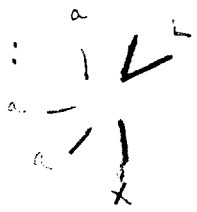
3. Vicia - Levan. With certain treatment, break occurs at the nucleolus organizer quite predictably.

4. Dreyfus -- break in arm of particular chromosome at certain division in the spermatogenesis of

5. Catcheside - Oenothera. His case of position effect following translocation: Evidence much like that found for Ds. Chromosome breaks; chromosome duplications and deficiencies of certain region of a chromosome in the translocation complex.

XVI. Conclusions:

1.

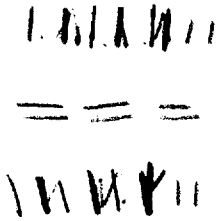
Egg:  × Sperm 

Zygote 

First 4 cleavages = ordinary mitosis

Separation of germline + soma

Soma



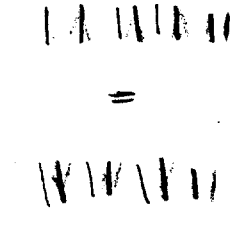
5th to 6th div

Germline

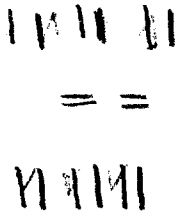
elimination of 1 V DT from soma

7th div

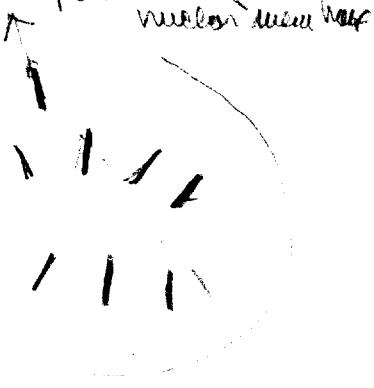
To become ♀



To become ♂

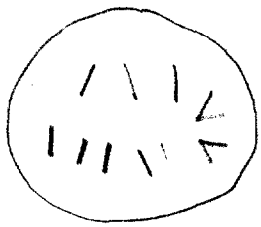


elimination of ♀ 1 × Chr.

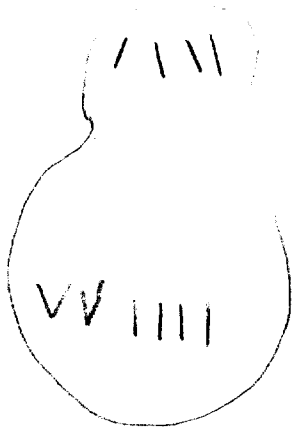


The spermatogenesis - meiotic division.

Prophase: no synapses



Anaphase I



→ Bud; complement form of 1 of 2 centrioles and x
Does not develop sperm

Anaphase II

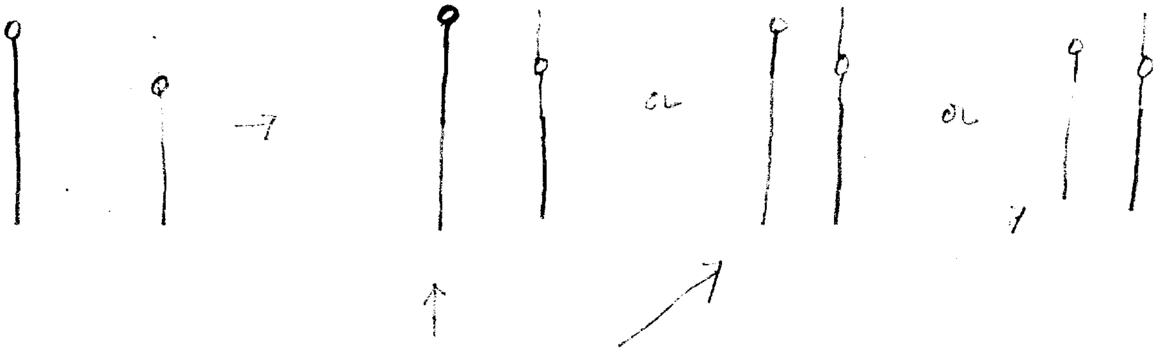
↓

↑ ∧ III → non functional cell.

VV IIII II → sperm nucleus
= =
1 set of chromosomes from meiosis
2 x chromosomes from meiosis
2 haploid chromosomes.

Sciara – The translocation studies of Crouse.

1. Scoring X – autosomal translocations

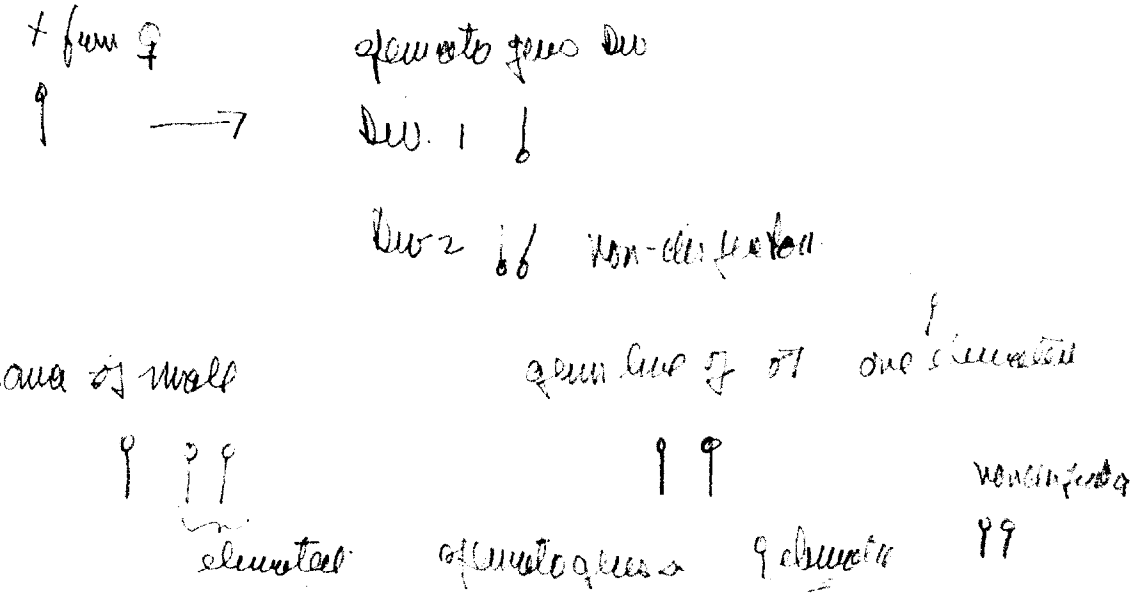


i) non-disjunction in [illegible]

2) Eliminated in cleavage divisions in soma; through nuclear membrane in germ line

2. The control exerted on bz by the centromere (region?) of X chromosome, not a component of the elimination in this chromosome as a whole.

3. Alteration of controls in alternate generations: not the effect of a particular centromere which remains undifferentiated. It becomes differentiated at some time.



4. Differences must be imposed on the homologues at some time during development and then at the centromere of X chromosome which prepares it for the recombinations.

The B-type chromosome in maize –

1. Nature of B-type ch. Extra chromo; not like any in normal complement. Found in many strains of maize

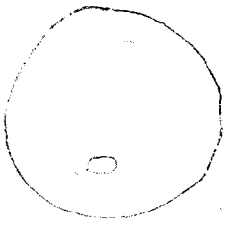
2. The internal morphology of the B-type ch.

3. Behaviour of B-type ch. in mitosis –

Divides in each mitosis along with regular set of chromo.

Occupies a particular position at edge of plate.

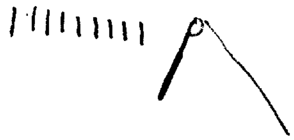
4. Behaviour in pollen grain divisions: Differential division

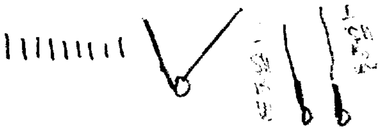


5. 2 types: one with no B; 1 with 2 Bs.

6. Translocations between A + B chromos:

7. The differential division in pollen

a)  No I Sh Bz Wx

b) 

8. Functionality of sperm in cross with C sh bz wx:

Endosperm with a) = C sh bz wx in phenotype
Zygote " b) = Rep. of I Sh Bz Wx

Endosperm with b) = I Sh Bz Wx
Zygote " a) = Plants = [illegible]

9. Again, region of centromere responsible for the non-disjunction in the pollen division.

The mosaic salivary gland in Sciara species cross. – Metz

1. S. ocellaris ♀ × S. reynoldsi ♂.

2. Salivary band structure of each recognizable.

3. The hybrid – one individual – 2 components of gland

mosaic party → gland. 29 cells.

← all cells have expected hybrid constitution i.e. set of o. + 1 set of r.

16 cells = expected chromosome constitution.

1 cell = " " " + 1 extra chromosome from o.

12 cells = all have 2n but all are ocellaris chromos.

4. Distribution of 12 cells = not contiguous. Appears as if same event occurred in making different cells.

a) None of mosaic cells reynoldsi = ♂ complement

q. Interpretation Metz: is this an example of out-of-phase action normally occurring at meiosis: expulsion of chromosome complement of ♂?

I. We already previously have shown that mRNA appears in the nucleus that differ in quite recognizable ways from those normally prepared for the gene:

1) We have recognized the gene as an independent entity, occupying a specific locus in a specific chromosome

2) We have convinced that this gene operates in a particular way - it is responsible, at least, for the organization of molecular components which influence the enzymatic biochemical reaction in the cell.

3) We have convinced that each gene functions to its extent in its own particular way

4) We have convinced that during the mitotic cycle, each gene is reproduced, namely accurately, so that the sister chromatids are alike in their gene genetic constitution.

5) We have not been so precise in our thinking of the changes that occur at the gene locus when a mutation occurs.

a) A few geneticists have declined to consider a mutation as a change in structure of the gene entity in such a way that it adequately functions to produce a modified molecular component which then enters into the biochemical process. This would be a real gene change.

b). The studies in Drosophila of position effects, first appreciated and defined by Sturtevant, opened up a wide field of research. Knowledge gained from these studies, a ~~complex~~ series of modifications of the view of mutation as a primary change in structure of the gene entity, and superimposed caution in projections of the nature of change at the genic level that is responsible for the observed mutation.

c). The position of gene entities along the chromosome remain. We know that if some alteration occurs in a locus of a gene a particular locus occ in the chromosome, a particular genetic type of alteration could occur.

d). Many regions in the chromosome, however, where no change of a mutational type could be obtained. Instead, changes produced ... This extends: alteration of many regions result in inviability. This leaves a big blank in our knowledge of genic composition of the chromosome.

II. In the maize studies, two concerned, a second system of chromosome + molecule control is superimposed on the known recognized system of stationary genes.

1. This system is composed of recognizable, specific genetic units, but these units are not stationary. They can move from one location to another

2. These units differ from the stationary units, in that they can control the action of the stationary units.

3. These movable units have specificity. There are different types of these units, forming specific systems, such as the Ds - Ac system, the "a," unit - Dt system; the "pg" - En unit of petunia. The action of a gene, in the case of the various unstable genes, reflects the behavior and specificity of the particular controlling system in action at the locus of the stationary unit - Examples of A,:

1) System "a," - Dt
2) " Ds - Ac
3) " a,m-1
4) " a,m-2

Each system differs in its mechanism of control of the gene expression of the stationary A, unit.

II. We outlined the events of the various changes that occur to chromosomes when a chromosome is breaking during the b-f-b. cycle and discussed that certain chromosomal components - the centromere, the knob, the nucleolus organizer, were being altered by this process.

1). We have indicated that in plants that undergo this b-f-b, the systems controlling gene action were made evident

2). We outlined one test that supported the assumption that the b-f-b. cycle could expose such units - the a,/a,m b-f-b cycle showing

to induce mutation at a_1.

3) We have shown that new mutable genes can arise in plants having a mutable gene and that often the system operating at this new locus is the same as that known to be present in the plant -- the numerous cases of origin of Ac controlled mutability when Ds + Ac are present.

4). We have outlined our knowledge of the events that occur at the locus and came to the conclusion in the Ds-Ac case, that the change in phenotypic expression was not due to a change in the gene ~~gene was not mutating~~ but that the changes occurring were associated with changes of the Ds unit which controls the degree + type of action of the gene.

5) We have given the evidence which suggests that the type of change is a result of some physical alteration in the chromatin material of at the Ds unit.

III. We are left with the problem of accounting for the appearance of these gene controlling systems: Where do they come from? Why did they appear in these plants that underwent the b.f.b. cycle?

IV. My speculations on them run somewhat as follows:

1. These gene controlling systems are always present in nuclei
2. They operate in "normal" nuclei just as they do in our mutable strains during development, controlling the action of some genes in the same manner + with the same precision.

3. They were made evident to us because their time of operation was thrown "out-of-phase" during the developmental cycle: they are acting at times not associated with the normal cycles. 6.

4. The mechanism responsible for this is associated with the alterations in the heterochromatic elements of the chromosomes

5. Changes in the quantity and mutual association of the heterochromatic elements in some manner initiates changes in the time of action of the mobile gene controlling units. These mobile units need not be composed of the material of the heterochromatic elements but changes in these elements affect the action of the mobile units, putting them "out of phase" in the periods of action; once out-of-phase, they remain that way, allowing their mode of operation to be discovered.

6. On this view, we are not creating any new phenomena, nor have we introduced a new condition, such as a virus, that would be responsible for the results obtained.

7. Do not patterns in development suggest the presence of such units? Such simple patterns as the position, the size, + the inheritance phenomena of the pigmented spots on the of the Lady Beetle? Why does pigment appear only at certain places + at certain times in the formed individual which reflects the control of such pigment formation in development? What about the R locus in maize that shows such

precise controls in the distribution + intensity of pigment in different tissues and parts of tissues in an organism? Why are there so many alleles of the locus, each showing specific action with respect to these different + intensity within the same plant? Could there be reflection of the action of controlling units? Are changes occur during development at specific times + in specific cells that control when + how much pigment will be found in the different cells?

8. If the assumption made above was true, then, the quality of an organism should not be alike but should differ from one another in very precise ways.

9. The evidence for difference in the genetic content of cells, and the evidence of how these differ is vast. To adequately consider this evidence would require a whole series of lectures.

10. I will try, nevertheless, to outline some of this evidence, in order to indicate the range of differences and the quality of their origins, when this is known. Only examples of some types, by no means all types, can be given at this time.

11. There range from differences involving number of sets of chromosomes to differences involving known genes, or both of morphological and physiological levels.

changes in chromosome constitution at certain times during development.

I. Polyploidy - "normal" individuals

1. Wide spread phenomenon. Certain cells of organism are polyploid -

Degree varies from 1n to 2,000 n.

Dispersion of chromos in nuclear cells - ① polytene, ② individual strands. ③ combination.

2. Mode of producing polyploidy - varies: Endomitosis; nuclear fusion; suppression of spindle separation.

3. Expression - a) Polytene chromos in diptera - very well known

b) Polyploid cells in plants - " " " characterize certain cells in a tissue

c) Same applies to animals.

4. Not only increase in chromo constitution characterizing particular stages, but also decrease in chromo constitution

a) Most familiar = meiotic division

b) Less " " = Reduction in early developmental stages =

Frog (Briggs, 1953) - in tail of frog, the mesenchyme cells have reduced chromo number. Many of them have the 1n number.

Sea Urchin - (Lindahl, 1953) - 16 cell stage, 4 micromeres from vegetal pole. all with 2n = 36.

During the micromeres: reduction = cells found have 18 chs (genome still full contained).

II. Changes in constitution during development - specific chromos.

1. Best case became best studied - Sciara.

Outline: the origin of sperm constitution
" " " egg "
the female = soma
a) Losing limited chr
b) " " " extra x chr - which ones
Loss in germ line: extra x chr -
the region controlling loss = centromere.

2. Others - Cecidomyidae - White -

3. Differences within nuclei having polytene chromos:
a). Whole chromos - White, Hubbard, Brown.
b). Parts of chromos at certain times during development -
Beermann, Mechelke, Pavan.
① The Pavan studies: Outline.
c. Schultz - the Y chrom nucleoli.

III. The changes in constitution of nuclei at specific times -
a) the B type chr: many organisms.
b) the component responsible in maize. A-B translocation. the centromere region or close to it = as in Pavan.

IV. The changes in gene action occurring at specific loci -

a) Mating types: in Paramecium

b) " " : in Fungus Glomerella.

V. Alterations induced by Di-Type behavior - breaks at specific loci

1. Sciara - Metz - genetic transmission
2. ~~Campanula~~ Hyacinth - breaks at specific loci - loci in development
3. Vicia - Levan - breaks at specific loci when seedlings grown with low oxygen content
4. Drug fos: breaks at specific loci during spermatogenesis
5. Oenothera - Catcheside: " " " regions (loci) in a translocation chromosome.

VI. Specific associations of chromosomes in cells -

1. Maize - association of knobs - 9 + 5 very high at pachytene - S. Palau

" " centromeres - non-random " " "

2. In differentiated cells of plants: Treatments: force differentiated cells to divide: Breaks + fragments. Their relation to one another in polyploid cells

same time
same place

Reflect associations in resting nucleus.

VI. Differences in behavior of chromosomes within a nucleus:

a). One set of chromos = all condensed = stain very differently from the other set

b). " chromo = " " at one stage; differ, like other ones at another stage.

c) One region or band of a set – differences at different stages of development within set chromos of nucleus.

VII. Conclusions:

1. The different nuclei of an organism can vary in their gene constitution in a very wide range of possible ways: From differences in organization or behavior at specific loci to differences in whole chromos, to differences in whole sets:– Presence or absence; increase in quantity or decrease in quantity; differences in division roles; differences in structure – at all levels from a band to a whole set of chromosomes.

2. In the light of this knowledge, the origin and behavior of mutable genes, as outlined, is not a fantastic projection, but a working hypothesis with much latitude for future experimentation to define, modify and refine our appreciation of the various systems within the nucleus which operate to control the expression of genes during the developmental process.

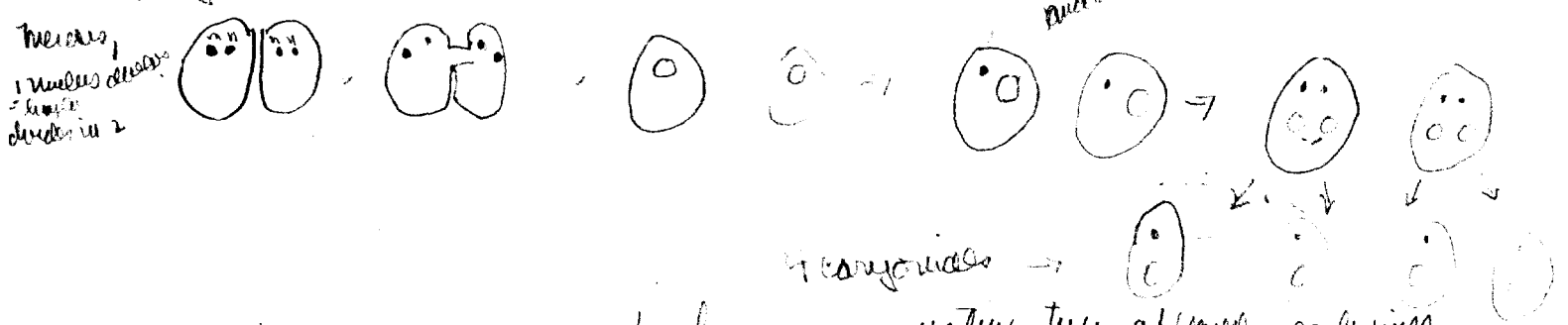
Nanney, D.L. + P.A. Caughey

1953

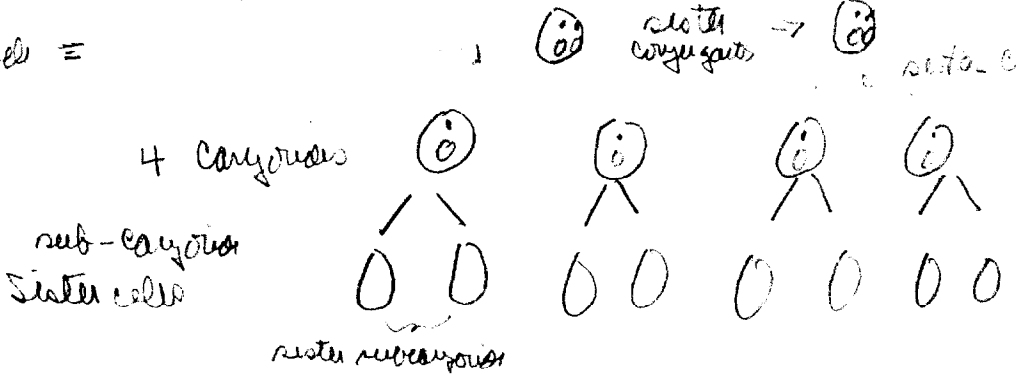
Mating type determination in Tetrahymena pyriformis.

Proc. Nat Acad. Sci 39: 113-119

1. In P. aurelia, no more than 2 mating types found within a variety (given I : II, ... : IV ...)
2. Tetra. pyriformis: wide variety of forms
   1) amicronucleate, no known asexual form
   2) "selfing" lines
   3) crossing clones. This type used: Brooks Hab 14, Brooks Hab 6 : mating type I, mating type II
3. Life cycle:



4. Among 500 F_1 F_2 + F_3 and back cross, 7 mating types appear, each will mate with another type but not with itself
5. Selfing clones also appear. These give as many as 4 mating types within clone, but individual isolates give rise to pure mating types
6. In P. aurelia (Sonneborn) mating type within individuals of conjugating pair usually alike but mating type produced by sisters (after conjugation) often differ. Mating type "segregates" at 1st division of macronucleus. Type of change.
7. The tetrahymena results: Separated cells from 4 conjugates mate three produced by conjugates =



all possible comparisons of mating type in related clones tested. Results of 3 exp. shown in table 2.

Table 2 of paper

Cross	Sister sub-caryonides alike	Sister sub-caryonides different	Sister caryonides alike	Sister caryonides different	Co-conjugant caryonides alike	Co-conjugant caryonides different
1	7	6 (1)	16	28	18	73
2	7	1 (1)	6	12	10	27
3	13	4 (1)	10	22	14	59
Totals	27	11 (3)	32	62	42	159

( ) = number of sub-caryonides in which different pure line types were found: Delayed segregation, delayed change in nuclear constitution

Nearly all possible combinations were found within sister caryonides: [illegible]

8. Crossing same mating types, - III × V from F2 individuals, as examples -- yielded only selfed mating types. And, different alleles of II or V gave different spectra of types

Table 3 of paper:

Cross	Temperature	mating types of caryonides from III × V F2 individuals I	II	III	IV	V	VI	VII	Selfing culture	Total
4	16°C	2	5	4	0	5	13	0	9	38
	26°C	12	3	4	0	3	4	0	9	35
5	16°C	0	5	4	11	2	0	2	14	38
	26°C	0	11	1	9	2	0	4	16	43

Interpretation (mine)

Results suggest an unstable locus determining substance responsible for mating type. In P. aurelia, time of change at locus occurs, usually, at first division of macronuclei in sister conjugants, about to two parental type. In Tetrahymena, time of change has greater spread, going into sub-conjugant division but mainly at first division of macronuclei. Here, type of change can give a number of new mating types, not formed in parents reaction types.

Time and type of change in nuclear constitution illustrates. Related to mitotic event.

Auto - mutagenesis in the Mushroom, Schizophyllum commune

John R. Raper, Univ. of Chicago. Science 118 pg 574, 1953 (NAT).

1. Tetrapolar sexuality; obligate crossmating imposed and controlled by incompatibility factors at two loci, A + B.
2. Each fruit produces progeny of 4 distinct mating types
3. Fertile matings occur between strains of these diverse mating types only in those combinations which yield the double heterozygote.
4. In other combinations having A + B factors in common, heterokaryons of a unique type are formed.
5. The common - A heterokaryon, which is stable and capable of indefinite vegetative growth, induces mutations in its component nuclei in frequencies up to 10^6 times the same spontaneous rate for the same mutations in homokaryotic strains.
6. Mutants belong to a limited number of distinct morphological types (about 12) each differing from the wild by a single, characteristic, altered locus.
7. Age of heterokaryon + genetic history of its component strains determine mutation frequency and, to a lesser extent, the type of mutation induced.
8. Auto-induced mutagenic agent(s) suspected which preferentially affects a limited number of loci in a regular and predictable manner.

Hinton, T., P. T. Ives & A. T. Evans

Changing the gene order and number in natural populations

Evolution 6 : 19-28

1.

1. 13 X chr. mutant stocks examined derived from br of Ives.

2. Each carries inversion from c.o. studies

3. Arose in br stock with frequency of 4.8% of tested lethal-bearing chromosomes

4. Kept in stock by balancing with Δ-49.

5. Crossed to normal & salivaries examined

		Breaks	
Breaks.	In (1) br 1	12 E	20
	" 2	1 F	20
	" 3	4 D	20
	" 4	4 C	20
	5	1 F	20
	" 6	4 C	20
	" 7	12 E	20
	" 8	3 C	20
	" 9	8 F	20
	" 10	4 E 2, 3	8 A, 1, 2
	" 12	1 C 3	20
	" 13	4 E	20

Transposition (Ch 11) Break at 5C, 7E, 20. Region between 5C and 7E inserted into 20.

nearly 1/2 of breaks occur in region 4.

Regions involved coincide with position of hetero chromatin given by Kaufmann

Break positions in 20 not determined cytologically. Crossover studies suggest different positions of breaks in 20.

Species crosses - interaction nuclear complements

I. Many examples - changes in gene action,

appearance of variegation

Changes in chromosome constitution - reduction

Melz - Somatic changes in set - mosaic

salivary gland. Species A × B.

Some cells = Hybrid

" " = all of species B

" " = Part of A + B.

Mechanism - eliminating chromosomes in

F.C. A + B × A = B also

eliminates chromosomes

Ds type behavior – Besides maize.

1. Hyacinthus – Darlington. Particular chromo – breaks late in each part at specific region of a specific chromosome.

2. Sciara – Metz. Strain showing break at specific region of specific chromosome in strain of Sciara. Genetically Controlled.

3. Dreyfus – Break at specific region of certain chromosomes during spermatogonial divisions

4. Vicia – Levan – Breaks at specific regions in m.c. cells. in early development – cause environment.

5. Oenothera – Catcheside. Evidence strongly suggests Ds type behavior in chromosomes arising from translocation. Breaks at or close to heterochromatin.

Differential segregation – genetic, expression non-mendelian – [illegible]

1. Paramecium – mating type selection – [illegible] differ following this division. At certain time in development

2. Tetrahymena – [illegible] next following division

3. Case in Glomerella where "mutation" is genetically controlled in the development of the ascogenous hyphae. At certain time [illegible].

4. Control of patterns - why frequent floods at certain places
5. Wing of Cyclonic - different methods required.

Differences in number in different cells of an organism: Morphological Studies (1

1. Zygote = 2n = 2 sets of chromos.

a). Increasing number of sets – definite degrees in certain cells of tissues
widespread phenomenon
(2) nucleus – very commonly: Polytene
strands remain together.

Differ – strands

separated

combination of ideas

b). Decrease in sets of chromos – at particular time in development

(1) Frog – Tail mesenchyme cells haploid in
Epidermis = diploid

(2). Sciara – Somatic reduction in division of certain clearly differentiated cells of 16 cell stage of embryo – the chromo.

all 4 chromosome number = 2n (36
During their division = reduction in number to n chromos. (18)

(3) Pelecs (mosquito)

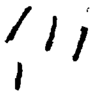
2. Differences in different cells of organism with regard to certain chromosomes of the complement: Sciara [chromosomes]

b) Maize – B type chromos. [the centromere ...]

c) Plants & animals – many cases like that of both Sciara & maize.

3. Differences in behavior of sets of chromosomes within a nucleus - Reflect differences in function.

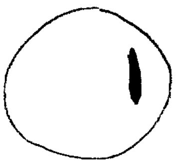
one set condensed - become chromocenter (White -



one set extended.

4. Differences in behavior of individual chromosomes in complement at different times & in different cells of tissue

a) White - salivary; Photo [illegible] - salivary.

b). Some cells  others

Different same

5. Differences in behavior of individual parts of chromosomes.

a) Large segment cells ↙ or ↘

b). Chromocenter region - Drosophila Somatic cells - [illegible] Salivary.

6) Smallest segment known - the bands in salivary glands - Pavan.
Rhynchosciara:

1) all eggs laid within 45 min

2). larvae = all of 1 sex

3) " develop all at same time 42 days to pupae.

4). Extracting ^(fluid) salivary gland type cells in several of the tissues

5). Can follow differential behavior of individual bands at any one time.

6). Showed: certain ^(individual) bands in particular tissue of all larvae undergo same type of change during development + same sequence of change. Reflects differential action at certain times in development. Pavan interpretation of the changes: increase in DNA, or of gene components, differentially in a particular band. Always same band, in same tissue at same time in development.

March 4th.

I. Review of previous discussion.

1. Purpose - to show that other systems present that control genetic expression besides the Ds-Ac + a,-Dt system, which are much older

a) To show that some basic similarities are present - that controlling genetic expression + timing, the cleavage somatic segregates + meiotic segregates that give the same change in gene expression.[1] Also, that initial evidence suggests homologies of the controlling factors.

c) Such hypothesis have also been proposed to account for genetic change in expression of the var. P locus in maize (by Rhoades) + another case of variegated pericarp given by Peterson.

II Since these controlling systems have undergone their alterations in cells whose nuclear composition has been altered, we infer that they were present in the nucleus before the alteration occurred. Performing in such manner -- controlling gene activity during cell division + in specific cell lineages

How can we account for their appearance:

If we take the view that they are present in the nucleus before alteration, then they must be functioning in some nuclei -- (1) They seem to control gene actions at certain stages of development (2) that the somatic segregations occur during tissue development. (3) that the cells in which such segregations occur do not give rise to the germ cells but to cells which will be differentiated

in one "set" line of determined course. (4). differentiation, + budding vegetation will not arise from cells which have lost components of the segregation process but can arise only from specific cells within the tissue, which have not been altered by somatic segregation.

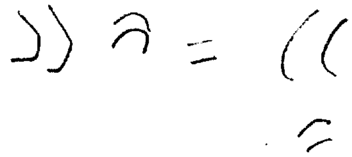
The reason we have been able to see this process is because the segregation process has "been put - out of phase" by the alteration occurring to the Activator-Dissociation elements by the b.f.b. cycle.

We can therefore examine this process because it is "out of phase" and determine the factors involved and how they operate.

This would require that (by hypothesis) in normal development the nuclei of different cells of an organism would vary genetically. They would not be equivalent to one another genetically. It would require controlled types of somatic segregation at specific times during development. It would suggest that chromosome alterations – translocations etc. – might accompany some of these changes. What evidence do we have that such events occur in normal development? There is a vast amount of embryological evidence pointing in this direction. Some representative examples will be chosen.

III. The "dedifferentiation" of differentiated plant cells:

1. Cells in root fully differentiated. Normally would not undergo a division
2. These forced to undergo a division by chemical treatment - (This treatment does not induce chromosome alteration in the dividing cell)
3. The chromosome complement -- chromosome alterations, present in nuclei, were evident in these cells. The polyploid cells arising from precursors.



The anaphase. Bridges & fragments. Two homologues 
Same aberration in each homologue. Expresses controlled event at same position in each homologue.

4. Such cells not capable of developing a new organism because of many aberrations present that are expressed at anaphase.

5. Conclude that the chromosome aberrations are of a controlled nature - association of particular components of the nucleus in particular cells.

IV. The controlled segregation of nuclear components during normal development. They occur on all levels - from chromosome sets to components of chromosomes.

1. Best analyzed case - Sciara. Many other cases with general pattern.
2. The B-type chromosomes in plants - Many cases - Examples B-type rye.
3. Gametic non-equivalence - Differential segregation

Paramecium mating types
Glomerella " "

V. Non-equivalence of chromosome components in normal development - all levels. From sets to chromosomes, to parts of chromosomes, to individual bands - genes - in chromosomes.

See sheet.